LONGEVITY, FERTILITY, AND POPULATION GROWTH STATISTICS OF *TELENOMUS REYNOLDSI* (HYMENOPTERA: SCELIONIDAE)

Ronald D. Cave and Michael J. Gaylor

Department of Entomology and Alabama Agricultural Experiment Station, Auburn University, Alabama 36849; Current address (RDC) is Dept. de Protección Vegetal, Escuela Agrícola Panamericana, Apartado 93, Tegucigalpa, Honduras, C.A.

Abstract.—Longevity and fertility of female *Telenomus reynoldsi* Gordh and Coker parasitizing *Geocoris punctipes* (Say) eggs were determined at constant temperatures of 20, 25, 28 and 32°C. Females lived significantly longer at temperatures below 32°C, but produced significantly more offspring at 28°C. Net reproductive rate was greatest at 25 and 28°C, whereas intrinsic rate of increase was highest at 28°C. Population growth statistics are compared to those of *G. pallens* Stål.

Key Words: *Geocoris pallens, Geocoris punctipes,* sex ratio, net reproductive rate, intrinsic rate of increase

Big-eyed bugs, *Geocoris* spp., are common predaceous lygaeids in many agroecosystems of the western and southern United States. Nymphs and adults consume immature stages of several crop pests (Champlain and Sholdt 1967, Ables et al. 1978, Lawrence and Watson 1979, Crocker and Whitcomb 1980, McDaniel et al. 1981, Ragsdale et al. 1981). For this reason, big-eyed bugs may be an important component of pest management programs.

The scelionid *Telenomus reynoldsi* Gordh and Coker is a solitary endoparasitoid of big-eyed bug eggs. Distribution of the parasitoid extends throughout the southern United States from California to Florida. Egg parasitism may range up to 65% in southern California cotton (Coker 1973) and Alabama cotton and soybean fields (Cave and Gaylor 1988b). Thus, *T. reynoldsi* may limit the impact big-eyed bugs may have in pest management programs.

Information concerning reproductive capabilities and longevity of *T. reynoldsi* is useful for evaluating the potential impact of this parasitoid on big-eyed bug populations. Nevertheless, little work has been done on these aspects of the adult biology of the parasitoid. Coker (1973) reported the fertility of 10 females at 27°C ranged from 47 to 107 progeny per female. He also found that adult longevity decreased with an increase in temperature from 16 to 32°C and increased when adults were provided with honey or with honey + water.

This paper presents the results of a study of longevity and fertility of *T* . *reynoldsi* parasitizing *G. punctipes* (Say) at four constant temperatures. Population growth potential of the parasitoid is described by four population growth statistics calculated for each temperature. These statistics are compared to those of another big-eyed bug, *Geocoris pallens* Stål (Tamaki and Weeks 1972), since population growth statistics are not available for *G. punctipes*.

METHODS AND MATERIALS

Parasitized *G. punctipes* eggs from a laboratory colony (Cave et al. 1987) were ran-

Table 1.   Reproductive statistics of *Telenomus reynoldsi* at four constant temperatures.

Variable	Temperature			
	20°C	25°C	28°C	32°C
n	21	20	20	20
Adult female longevity ($\bar{x} \pm$ SE)	17.7 ± 0.6a	16.8 ± 0.8a	17.0 ± 0.8a	12.4 ± 0.6b
Mean number progeny produced ($\bar{x} \pm$ SE)	14.1 ± 1.2c	39.0 ± 3.5b	51.9 ± 5.2a	41.1 ± 2.8b
Sex ratio (M:F)	1.5:1a	1.5:1a	1.6:1a	3.7:1b
Net reproductive rate (♀♀/♀)	4.3	10.7	10.5	1.7
Generation time (days)	35.3	21.0	16.1	13.1
Intrinsic rate of increase (♀♀/♀/day)	0.042	0.117	0.152	0.043

Means within rows followed by the same letter are not significantly different ($P > 0.05$; Duncan's multiple range test and χ^2 test of homogeneity of proportions).

domly assigned to controlled environment chambers and reared under constant temperatures of 20, 25, 28, or 32°C and a 14: 10 L:D photoperiod. On the morning of eclosion, adult *T. reynoldsi* females were transferred individually to plastic cups (30 ml) containing 10–15 *G. punctipes* eggs <72 h old and returned to the temperature and photoperiodic regimen in which they were reared. Each female was accompanied by 1– 2 males. A drop of honey-water was applied to the inside of each cup as a food source. Each female was checked daily for survival and, if alive, transferred to a new cup containing fresh hosts and food. Dead males were replaced with live ones. A water-saturated cotton ball was placed in the cup containing the exposed eggs and the eggs were incubated at 28°C in a rearing room. After 5 days, parasitized eggs were counted, separated from unparasitized eggs (Cave and Gaylor 1988a), and held for adult emergence. The sex of each emerging adult was determined. Hosts with parasitoids which failed to emerge were dissected and the sex of the parasitoid was determined if possible.

Effects of temperature on female longevity and fertility were analyzed using the GLM procedure of the Statistical Analysis System (SAS 1985) and means were separated with Duncan's multiple range test. The sex ratios of offspring produced at the different temperatures were separated using a χ^2 test of homogeneity of proportions. Each adult female was considered a separate replicate.

A survivorship and fertility table was constructed for wasps held at each of the four experimental temperatures by determining for each day (x) the proportion of surviving individuals (l_x) and the mean number of daughters per surviving female (m_x). The survivorship level at adult emergence was set as equal to the survivorship level previously determined for the end of the immature stage (Cave and Gaylor 1988a). From the survivorship and fertility tables, the following population growth statistics were calculated: R_0, the net reproductive rate, is

$$\sum l_x m_x \qquad (1)$$

for all age intervals; G, the mean generation time, is

$$\sum l_x m_x x_p / R_0 \qquad (2)$$

where x_p = pivotal age, which includes the mean developmental time of an immature female at the particular temperature (Cave and Gaylor 1988a); and r, the intrinsic rate of increase, is determined by substituting values for r into the equation

$$\sum l_x m_x e^{-r x_p} = 1 \qquad (3)$$

until equality is obtained.

RESULTS AND DISCUSSION

Longevity.—Mean longevity of adult female *T. reynoldsi* was significantly ($F = 11.3$; df = 77; $P < 0.05$) shorter at 32°C than at
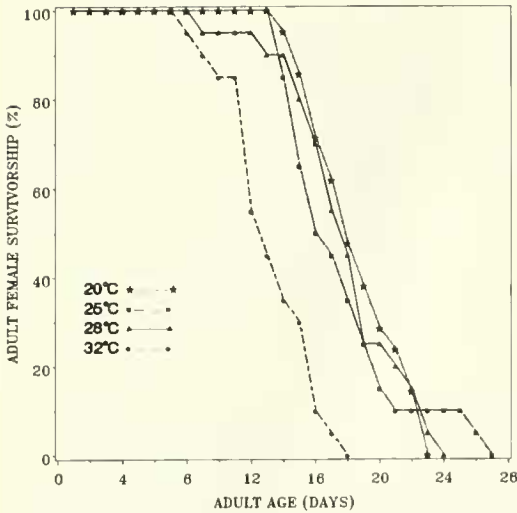
Fig. 1. Age-specific survivorship of adult female
Telenomus reynoldsi at four constant temperatures.

the other three temperatures (Table 1).
Maximum adult longevity at 20, 25, 28, and
32°C was 22, 26, 23, and 17 days, respec-
tively (Fig. 1). Coker (1973) determined
mean longevity of adult females at 16, 21,
27, and 32°C to be 34.6, 23.1, 20.3, and
17.2 days, respectively.

Survivorship at 20, 25 and 32°C was 100%
until nearly one-half or more of the maxi-
mum adult age (Fig. 1). Survivorship at 28°
was 100% until only one-third of the max-
imum adult age. Survivorship decreased
steadily after these periods until the last fe-
male died, except at 25°C where two females
lived 5 and 6 days longer than the third
oldest female.

Fertility. — Mean number of progeny per
female was significantly ($F = 21.8$; df $= 77$;
$P < 0.05$) greater at 28°C than at the other
three temperatures (Table 1). Fertility at
20°C was significantly less than at 25, 28,
and 32°C. The most progeny produced by
a single female at 20, 25, 28, and 32°C was
22, 80, 99, and 65, respectively. Coker
(1973) reported an average of 79.1 offspring
per female at 27°C; the maximum for a sin-
gle female in his study was 107. More male
than female offspring were produced at each
temperature (Table 1). The sex ratio was

significantly (χ^2 test of homogeneity of pro-
portions; $P < 0.05$) more skewed towards
males (79%) at 32°C than at the three cooler
temperatures. Since fertility at 32°C was not
significantly different from fertility at 25°C,
we concluded that the high proportion of
males produced at 32°C may have been due
to sperm inviability, which would have
caused unfertilized eggs to become males.
Also, different temperatures may unequally
affect mating activity, which ultimately af-
fects sex ratio. Sex ratios in the field are 1:
1 or slightly skewed towards males (Cave
and Gaylor 1988b). Contrary to our find-
ings, Coker (1973) found that female prog-
eny outnumbered males 3 to 2. The differ-
ence in sex ratio between our laboratory
findings and those encountered in the field
and those found by Coker may be influenced
by laboratory conditions, such as colony
density.

The fertility of *T. reynoldsi* is comparable
to that of other species of *Telenomus*. Year-
gan (1982) found that the mean number of
progeny/female *Telenomus podisi* Ashmead
was ca. 40 at 21°C. Orr et al. (1986) reported
the fertility of *Telenomus calvus* Johnson
was ca. 22 offspring/female at 27°C and that
ca. 32 offspring/female were produced by
Telenomus cristatus Johnson. Conversely,
Schwartz and Gerling (1974) observed that
Telenomus remus Nixon produced ca. 165
offspring at 25°C, although females lived
only nine days. A species that parasitizes
hosts in dense patches, such as *T. remus*
attacking egg masses of *Spodoptera* spp.,
might take advantage of high host abun-
dance by producing large numbers of prog-
eny at one time. However, species attacking
smaller egg masses (e.g. the pentatomid egg
parasitoids, *T. podisi*, *T. cristatus*, and *T.
clavus*) or widely dispersed solitary hosts
(e.g. *T. reynoldsi*) might have lower fertility
if they expend more energy reserves for host
searching and less for egg production.

Daily production of progeny by *T. rey-
noldsi* was highest during the first five days
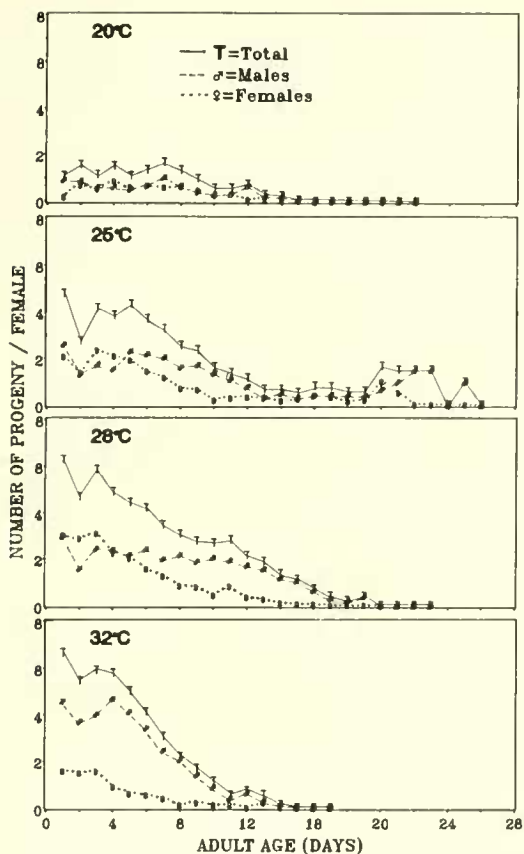of adult life at 25, 28, and 32°C (Fig. 2). At

Fig. 2. Age-specific fertility of female *Telenomus reynoldsi* at four constant temperatures.
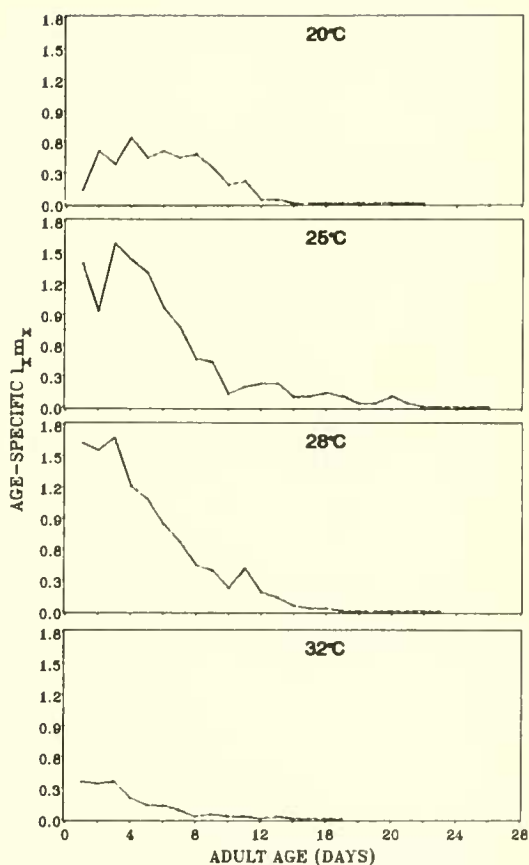

Fig. 3. Age-specific $l_x m_x$ values of female *Telenomus reynoldsi* at four constant temperatures.

28 and 32°C, fertility gradually declined after five days, but at 25°C it stabilized for seven days after declining for seven days. As reflected in the lifetime sex ratios, male progeny outnumbered female progeny on most days.

Most females oviposited within 24 h after emerging from their host. At temperatures ≥25°C, ca. 96% oviposited during the first day. At 20°C, ca. 63% of the females did not oviposit on day 1, and three did not oviposit during the first three days. Coker (1973) determined the preoviposition period of *T. reynoldsi* to be less than 6 h at 27°C.

Mean (±SE) number of days to completion of oviposition was 10.7 (±0.6), 12.8 (±0.9), 13.8 (±0.7), and 9.8 (±0.5) for 20,

25, 28, and 32°C, respectively. Maximum oviposition period was 15, 25, 19, and 14 days, respectively. Some females lived for several days after their last day of oviposition. Mean (±SE) postovipositional period was 6.5 (±0.9), 3.9 (±0.5), 3.2 (±0.5), and 2.6 (±0.4) days at 20, 25, 28, and 32°C, respectively. Yeargan (1982) reported that *T. podisi* also lived ca. 5 days after completion of oviposition.

Population growth statistics.—The reproductive contribution of each adult female age-class is represented by the product of age-specific survivorship and age-specific production of daughters ($l_x m_x$) as a function of age (x) (Fig. 3). At 25 and 28°C, the curves are similar, with the earliest ages contributing most (i.e. $l_x m_x$ values highest). Ages

2–8 contributed the most at 20°C. At 32°C, $l_x m_x$ values were highest the first few days, but were still as low as 25% of those at 25 and 28°C because of lower survivorship and fewer female progeny at 32°C.

Net reproductive rates (R_o) at 25 and 28°C were similar and more than 2- and 6-fold those at 20 and 32°C, respectively (Table 1). Mean generation time (G) decreased with increasing temperature. The mean generation time at 20°C was more than 2-fold that at 28 or 32°C. The intrinsic rate of increase (r) was highest at 28°C and lowest at 20 and 32°C. The intrinsic rates of increase convert to doubling times (ln 2/r) of 16.9, 5.9, 4.6, and 16.1 days. Although immature parasitoids develop fastest at 32–33°C (Cave and Gaylor 1988a), reduced survival of immatures, shortened lifetime, and low production of daughters at this temperature limit the population growth potential.

Population growth statistics have been estimated for only two other species of *Telenomus*. Hirose (1986) calculated an r_0 of 0.296 females/female/day at 30°C for *Telenomus dendrolimi* Matsumura attacking the eggs of the pine moth, *Dendrolimus spectabilis* Butler. Orr et al. (1986) found that the intrinsic rate of increase of the phoretic pentatomid egg parasitoid *T. calvus* at 27° was 0.149 females/female/day, which is similar to that found for *T. reynoldsi* at 28°C.

Population growth statistics have not been estimated for *G. punctipes*. However, these statistics have been determined for *G. pallens* and *Geocoris bullatus* (Say) (Tamaki and Weeks 1972). *Geocoris pallens* is a known host of *T. reynoldsi* (Gordh and Coker 1973), but parasitism of *G. bullatus* eggs has not yet been demonstrated. The net reproductive rate (26.8 females/female) and generation time (59 days) of *G. pallens* are more than twice those of *T. reynoldsi* at 25° and 28°C. The intrinsic rate of increase of *G. pallens* was 0.056 females/female/day, which converts to a doubling time of 12.3 days. These population growth statistics suggest that, although the host produces

twice as many daughters as the parasitoid, the parasitoid has greater population growth potential due to its shorter generation time and faster intrinsic rate of increase. However, as pointed out by Tamaki and Weeks (1972), *Geocoris* species may have quite different population growth statistics with different diets and physical conditions, and these conditions may at times favor the host.

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